Physics 129A

Introduction to Particle Physics

September 9, 2004

Introductory Lecture Part III

Announcements:

Problem set I is posted on the new Class web site

http://kamland.lbl.gov/~courses/129A/

Due Tomorrow, Friday September 10 5:00PM

Put in the box second floor LeConte Hall

Next week: review of relativity

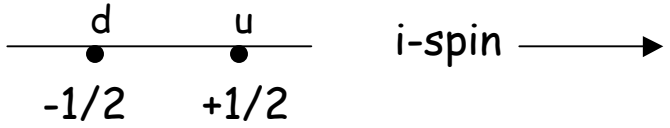
Please read Chapter 3 in Griffiths

and review the text you used to learn special relativity

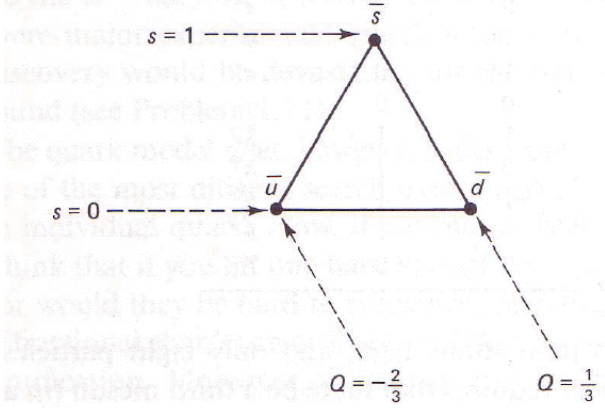
Flavor Symmetry --- Generalized Isospin

SU(2)

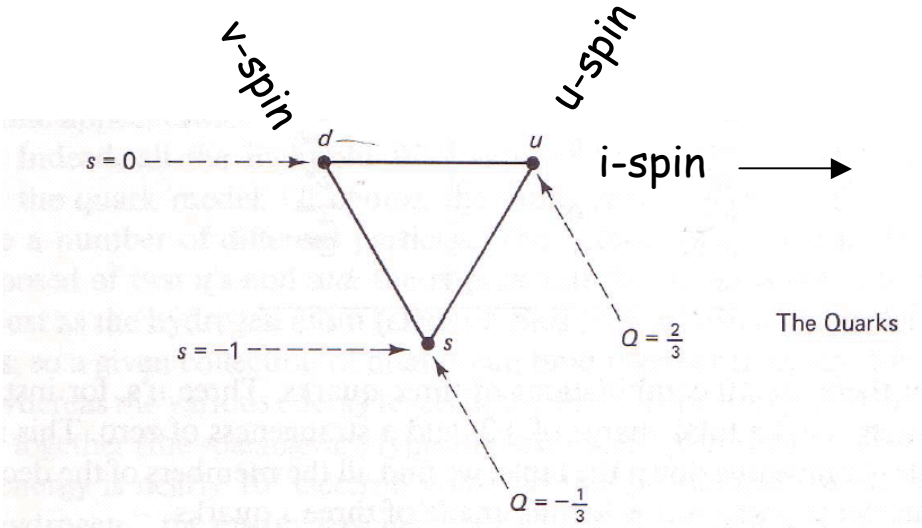
$$|p\rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \qquad |n\rangle = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$



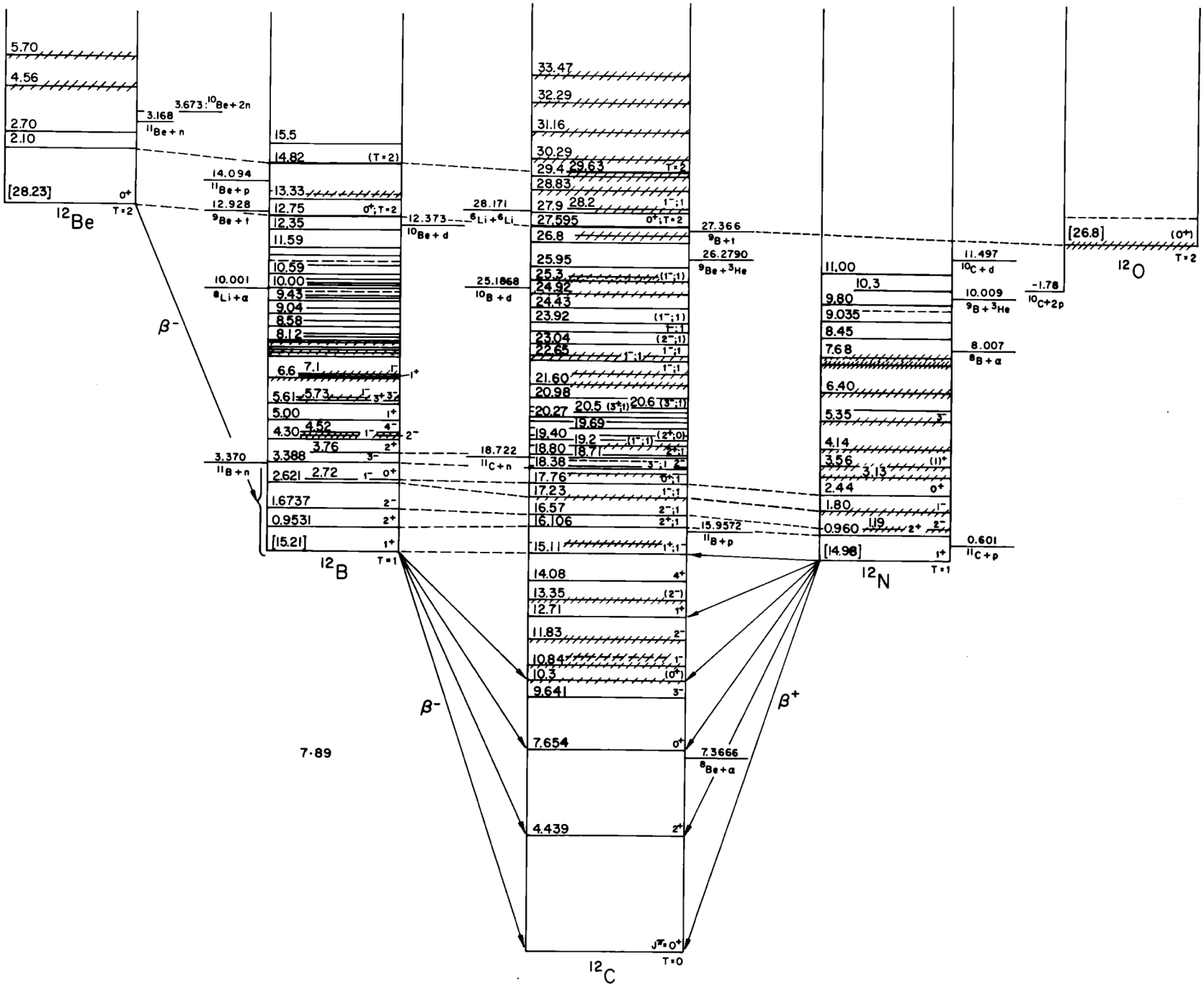
SU(3)



The Antiquarks

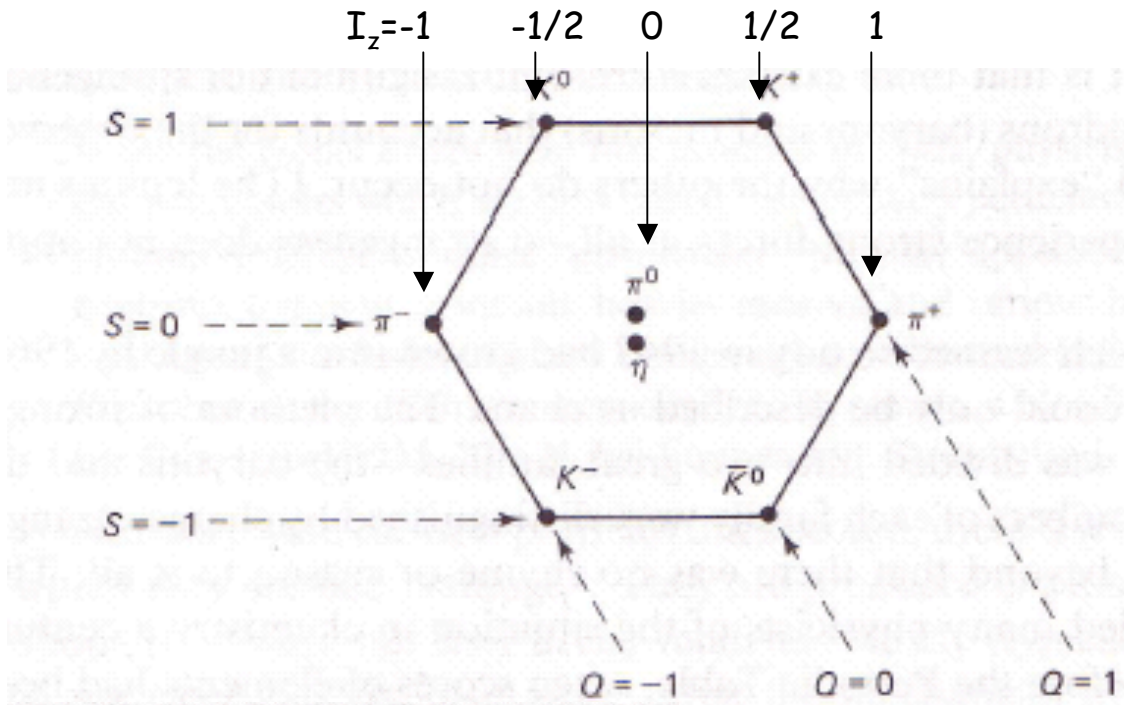


The Quarks


12Be
12B
12C
12N
12O
β-
β+
7·89

Mesons

SU(3)



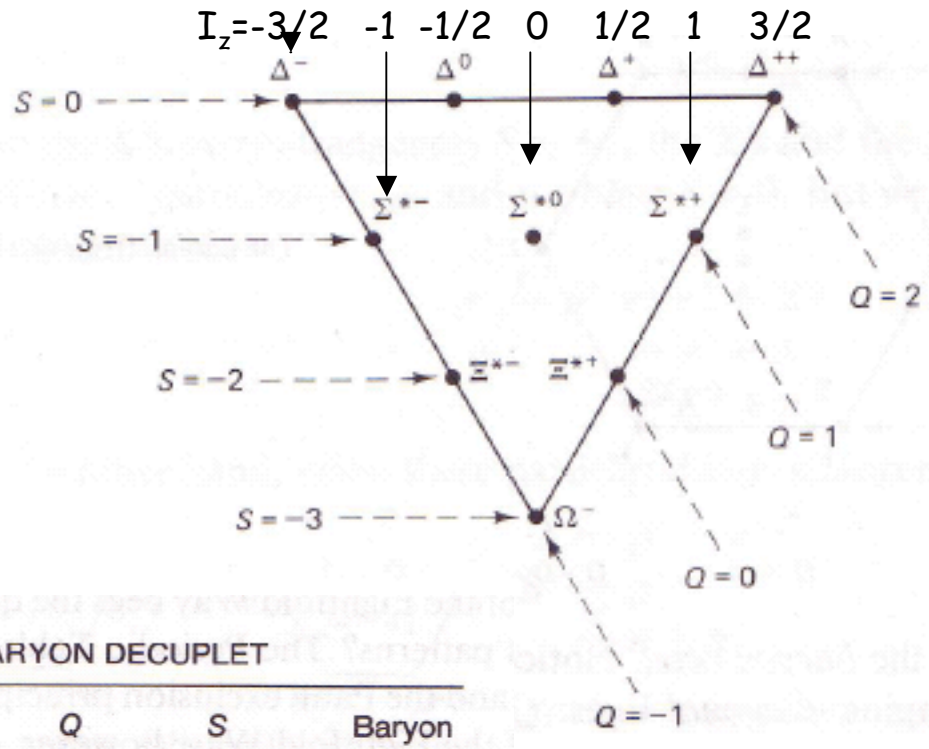
The Meson Octet

THE MESON NONET

$q\bar{q}$	Q	S	Meson
$u\bar{u}$	0	0	π^0
$u\bar{d}$	1	0	π^+
$d\bar{u}$	−1	0	π^-
$d\bar{d}$	0	0	η
$u\bar{s}$	1	1	K^+
$d\bar{s}$	0	1	K^0
$s\bar{u}$	−1	−1	K^-
$s\bar{d}$	0	−1	$\bar{K}^0$
$s\bar{s}$	0	0	??

$$3 \otimes \bar{3} = 1 \oplus 8$$

Baryon Decuplet



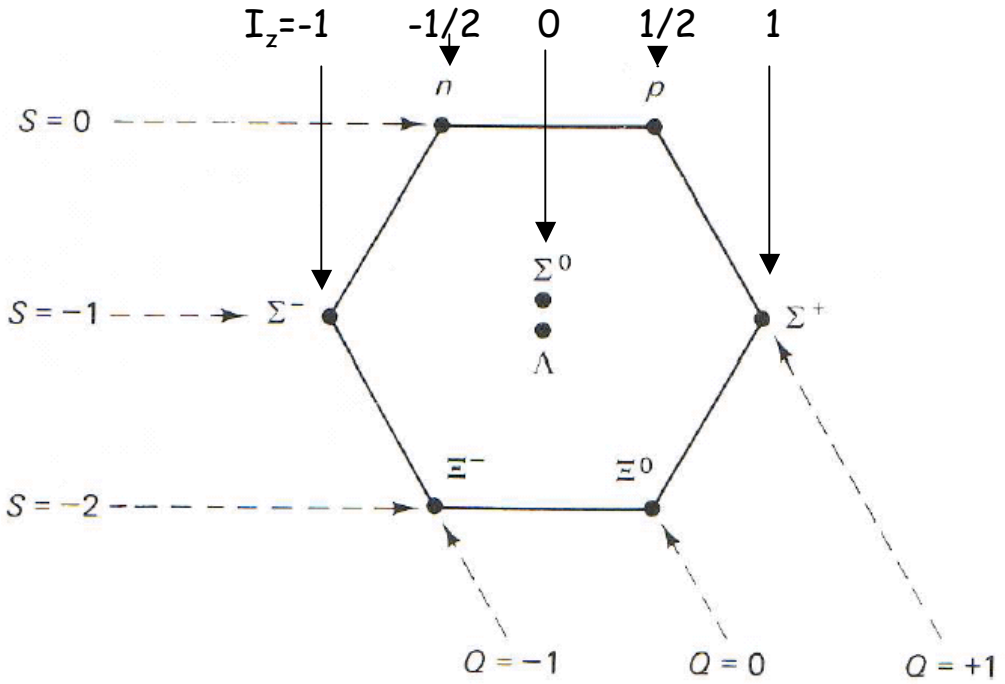
SU(3)

The Baryon Decuplet

THE BARYON DECUPLET

qqq	*Q*	*S*	Baryon
uuu	2	0	Δ^{++}
uud	1	0	Δ^{+}
udd	0	0	Δ^{0}
ddd	−1	0	Δ^{-}
uus	1	−1	Σ^{*+}
uds	0	−1	Σ^{*0}
dds	−1	−1	Σ^{*-}
uss	0	−2	Ξ^{*0}
dss	−1	−2	Ξ^{*-}
sss	−1	−3	Ω^{-}

Baryon Octet



SU(3)

The Baryon Octet

SU(4)

u, d, c, s

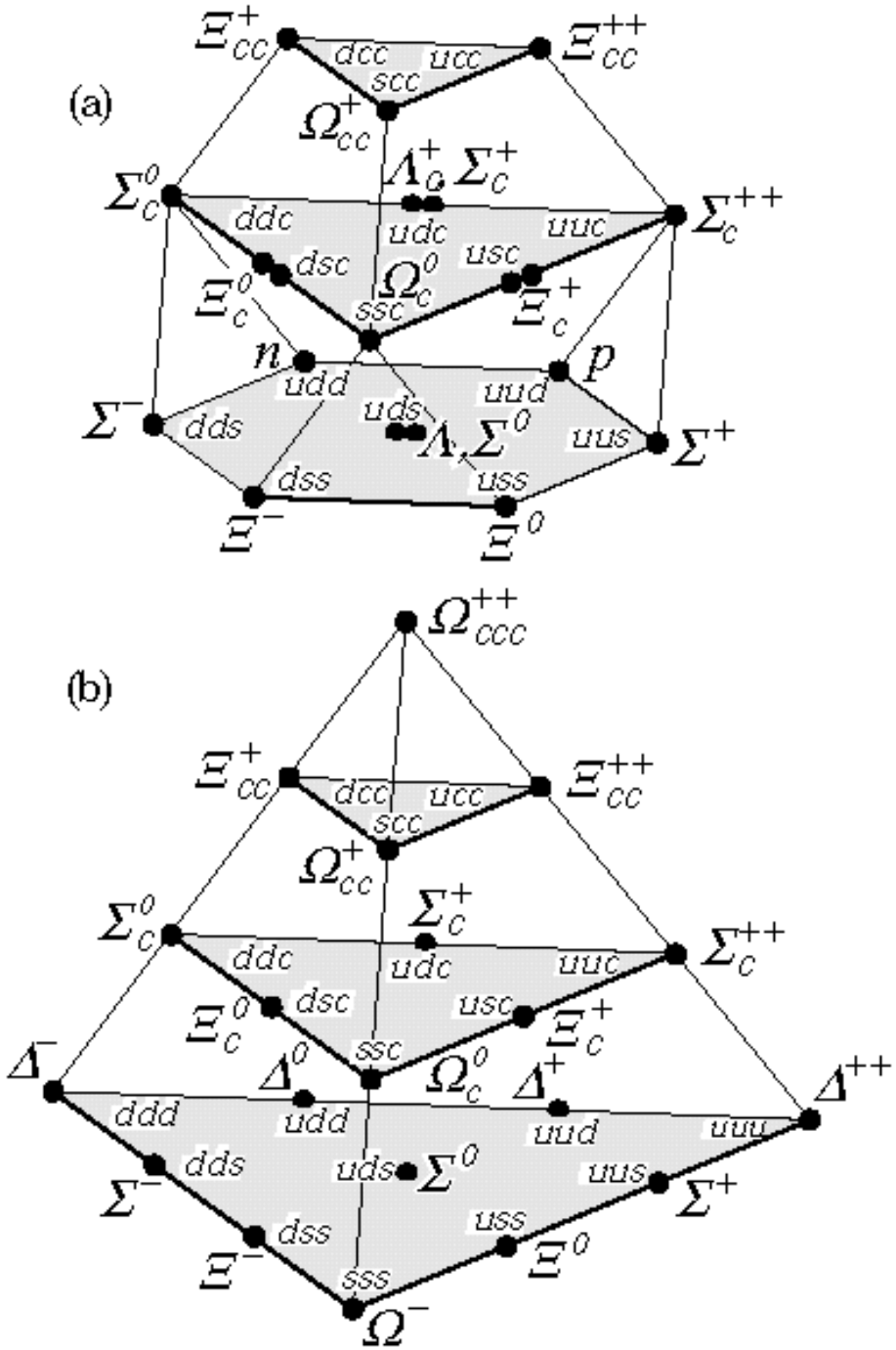

(a)
Ξ_{cc}^{+}
dcc
ucc
Ξ_{cc}^{++}
scc
Ω_{cc}^{+}
$\Lambda_c^+ \Sigma_c^+$
Σ_c^0
ddc
udc
uuc
Σ_c^{++}
dsc
Ω_c^0
usc
Ξ_c^0
ssc
Ξ_c^+
n
udd
uud
p
Σ^-
dds
uds
Λ, Σ^0
uus
Σ^+
dss
uss
Ξ^-
Ξ^0
(b)
Ω_{ccc}^{++}
Ξ_{cc}^{+}
dcc
ucc
Ξ_{cc}^{++}
scc
Ω_{cc}^{+}
Σ_c^+
Σ_c^0
ddc
udc
uuc
Σ_c^{++}
dsc
usc
Ξ_c^0
Ξ_c^+
Δ^-
ssc
Δ^0
Ω_c^0
Δ^+
Δ^{++}
ddd
udd
uud
uuu
dds
uds
Σ^0
uus
Σ^-
Σ^+
dss
uss
Ξ^-
Ξ^0
sss
Ω^-

TABLE 1.1

The Validity of Invariance Principles

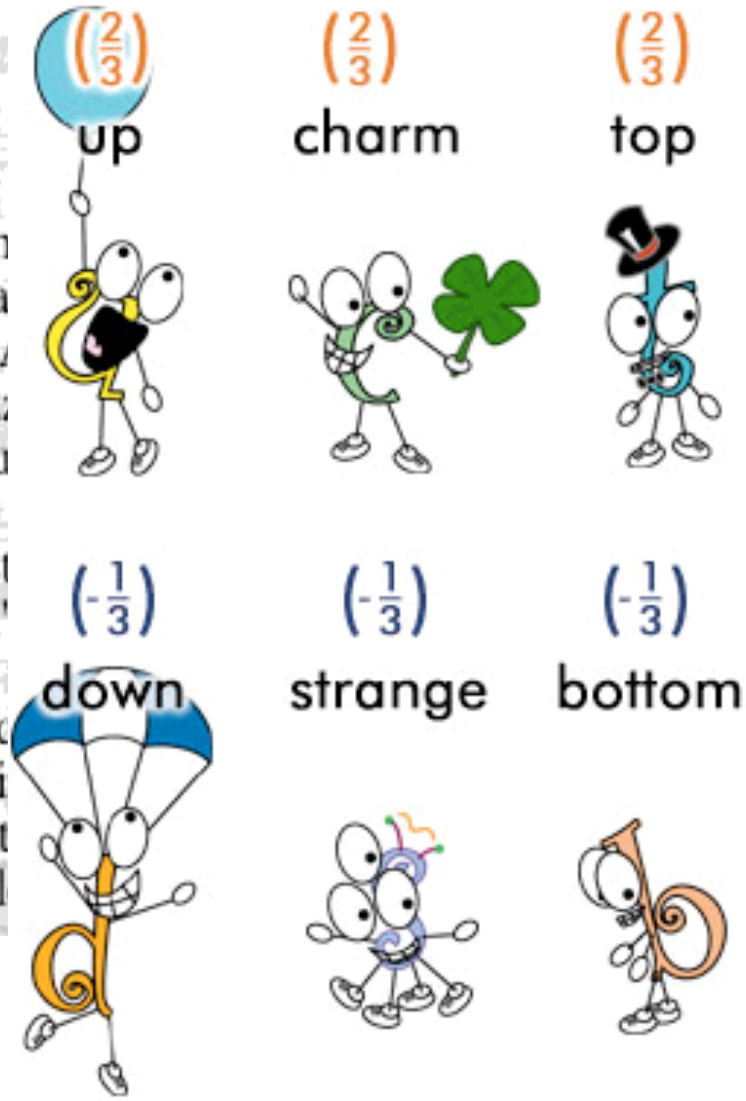
Symmetry operations or conserved quantities	Strong	Electromagnetic	Weak
Parity (space inversion)	yes	yes	no
Charge conjugation	yes	yes	no
Time reversal	yes	yes	yes?
Electric charge	yes	yes	yes
Baryon number	yes	yes	yes
Isospin	yes	no	no
Strangeness	yes	yes	no

Quark Model
Gell-mann and Zweig of Caltech
1964 A.C.E

Finnegans Wake

-- Three quarks for
Sure he hasn't got n
And sure any he ha
But O, Wreneagle
To see that old buz
And he hunting rou
Hohohoho, moulty
You're the rummest
And you think you'
Fowls, up! Tristy's
That'll tread her anc
Without ever winki
And that's how that
Overhoved, shrillgl

lark
the dark
by Palmer- stown Park?
ah's ark
l mark!
ns.



Search for Exclusive Free-Quark Production in e^+e^- Annihilation

A. Marini, I. Peruzzi, M. Piccolo, and F. Ronga
Laboratori Nazionali di Frascati dell' Istituto Nazionale di Fisica Nucleare, I-00044 Frascati, Rome, Italy

and

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Lawrence Berkeley Laboratory, Berkeley, California 94720

and

R. Fries,[a] B. Gobbi, W. Guryn, Donald H. Miller, and M. C. Ross
Northwestern University, Evanston, Illinois 60201

and

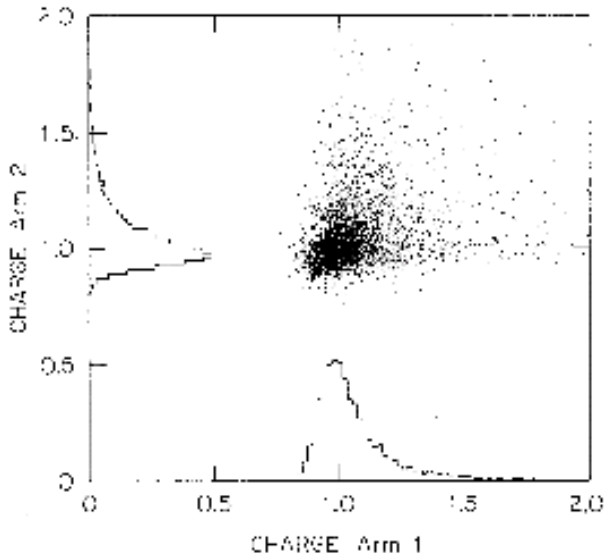
D. Besset, S. J. Freedman, A. M. Litke, J. Napolitano, and T. C. Wang[c]
Stanford University, Stanford, California 94305

and

Frederick A. Harris, I. Karliner,[c] Sherwood Parker, and D. E. Yount
University of Hawaii, Honolulu, Hawaii 96822

(Received 5 April 1982)

The products of e^+e^- annihilation at 29-GeV center-of-mass energy have been searched for free fractionally charged particles produced in exclusive two-body final states. No evidence for fractionally charged quarks was found and the upper limits on the ratio $R_{q\bar{q}} = \sigma_{q\bar{q}}/\sigma_{\mu\bar{\mu}}$ are below 1% for quarks with charges $\frac{1}{3}e$ or $\frac{2}{3}e$ and masses below about 14 GeV/c^2. This is the first reported limit for charge $\frac{1}{3}e$. Long-lived fractionally charged leptons are definitely ruled out over a significant range of masses.



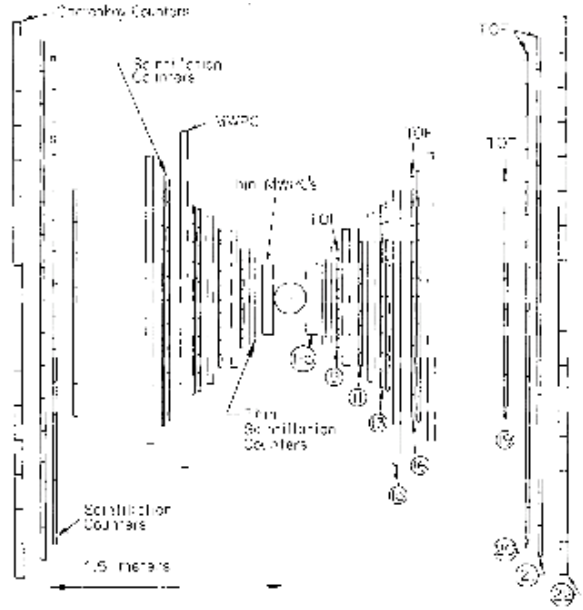


FIG. 1. Elevation view of the detector as viewed along the beam pipe. The elements are numbered sequentially from 1 to 22 moving outward from the IR (some of the layers are numbered in the figure). The "thin" MWPC's (layers 1 to 5) are not shown individually. Scintillation layers 9, 16, 19, 20, and 21 are equipped with TOF electronics.

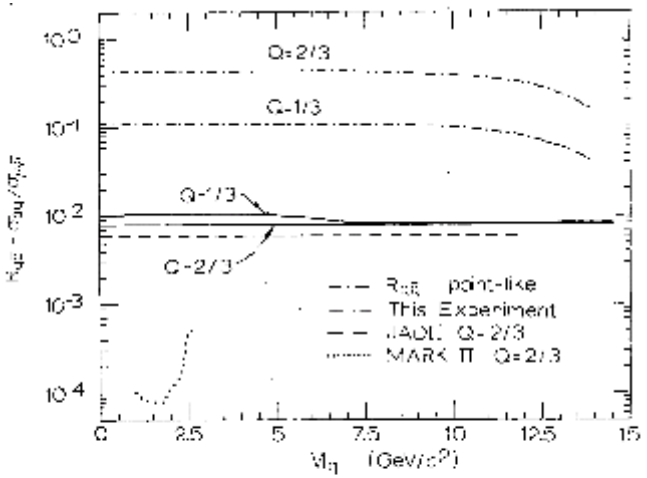
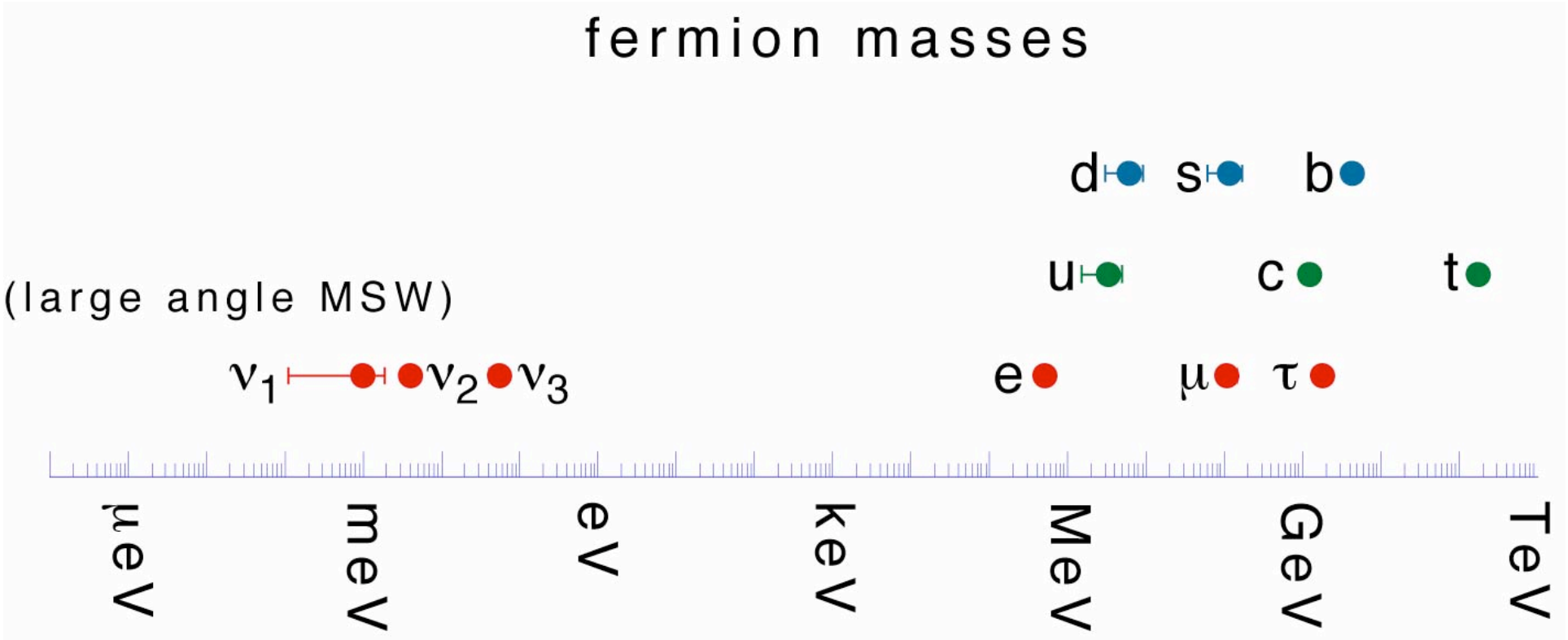


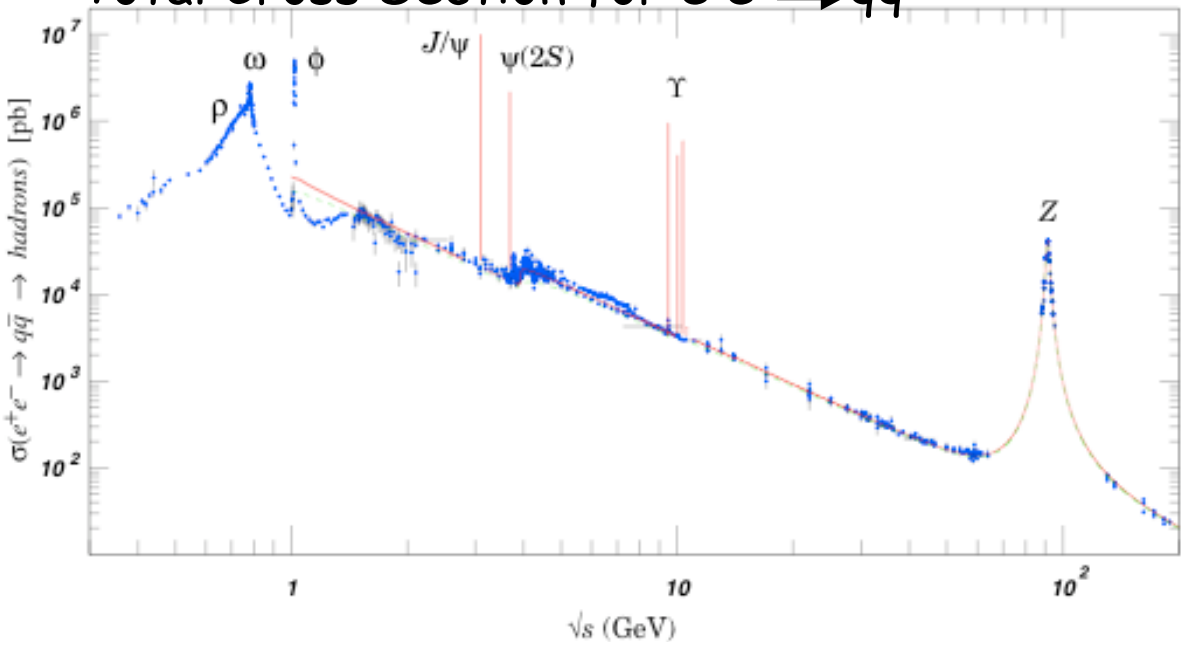
FIG. 3. Limits (90% confidence level) on exclusive quark production in e^+e^- annihilation. The limits for JADE are from Ref. 3 and the limits from Mark II are from Ref. 4.

Property \ Quark	d	u	s	c	b	t
Q – electric charge	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$
I_z – isospin z-component	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0	0
S – strangeness	0	0	-1	0	0	0
C – charm	0	0	0	$+1$	0	0
B – bottomness	0	0	0	0	-1	0
T – topness	0	0	0	0	0	$+1$

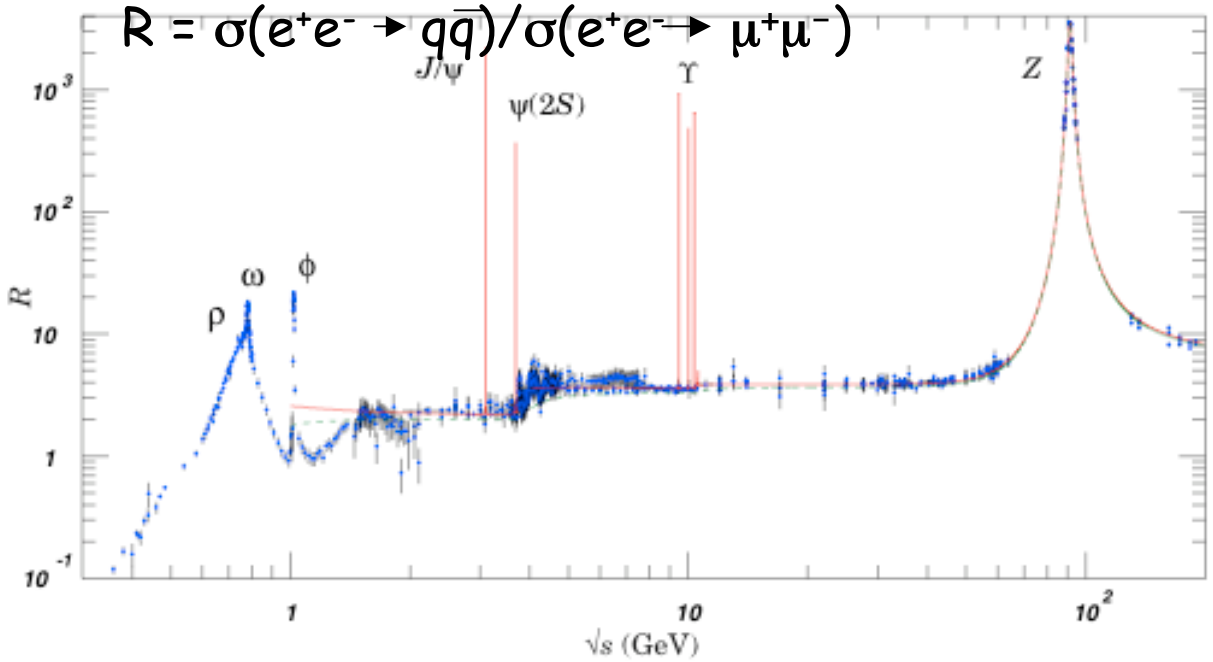
	Quark flavor	Bare mass	Effective mass	
			in mesons	in baryons
Light quarks	u	4.2	310	363
	d	7.5		
	s	150	483	538
Heavy quarks	c	1,100	1,500	
	b	4,200	4,700	
	t	Mass $m = 174.3 \pm 5.1$ GeV		


fermion masses
d
s
b
u
c
t
(large angle MSW)
ν_1
ν_2
ν_3
e
μ
τ
μeV
meV
eV
keV
MeV
GeV
TeV

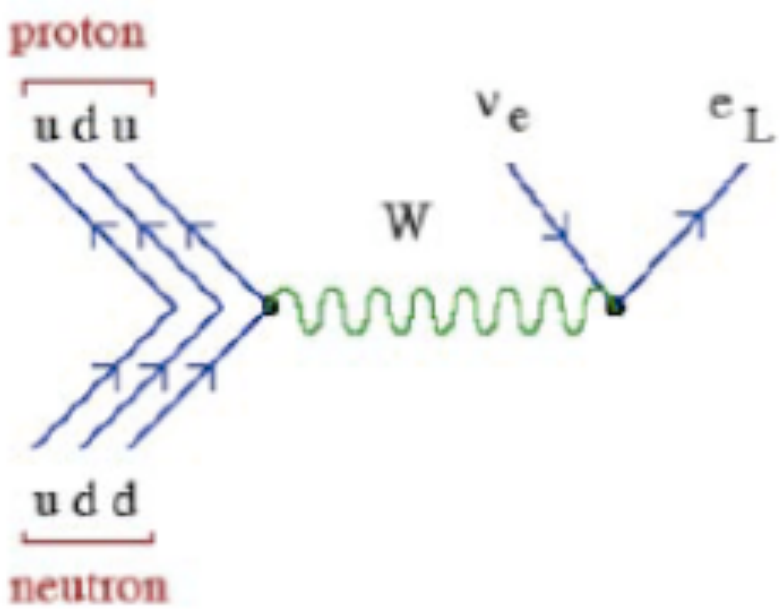
Total Cross Section for $e^+e^- \rightarrow q\bar{q}$

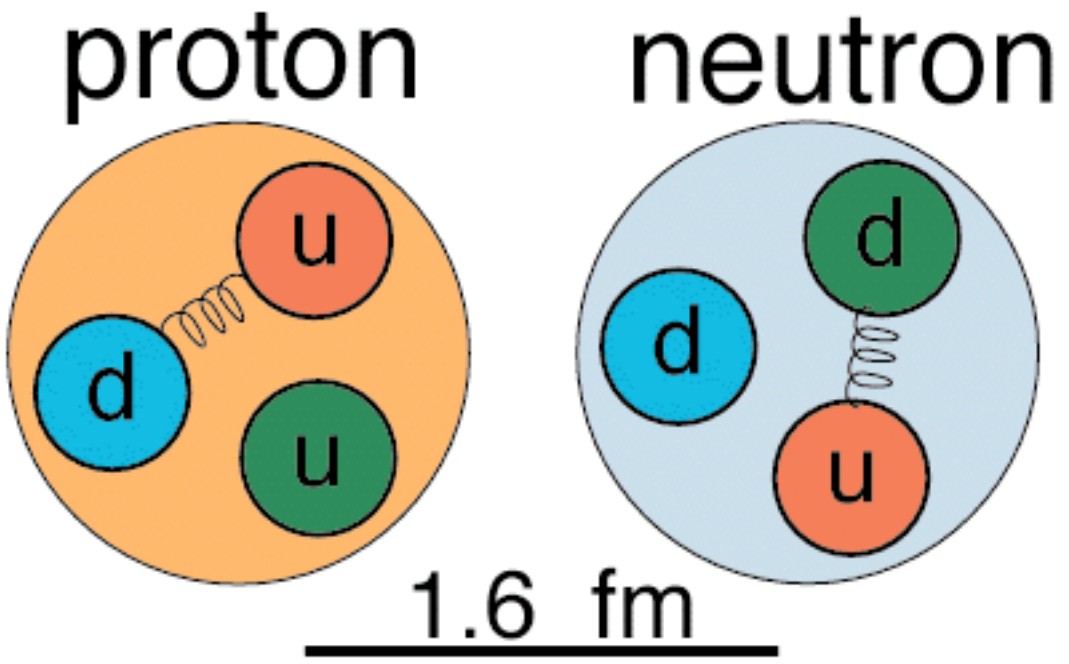


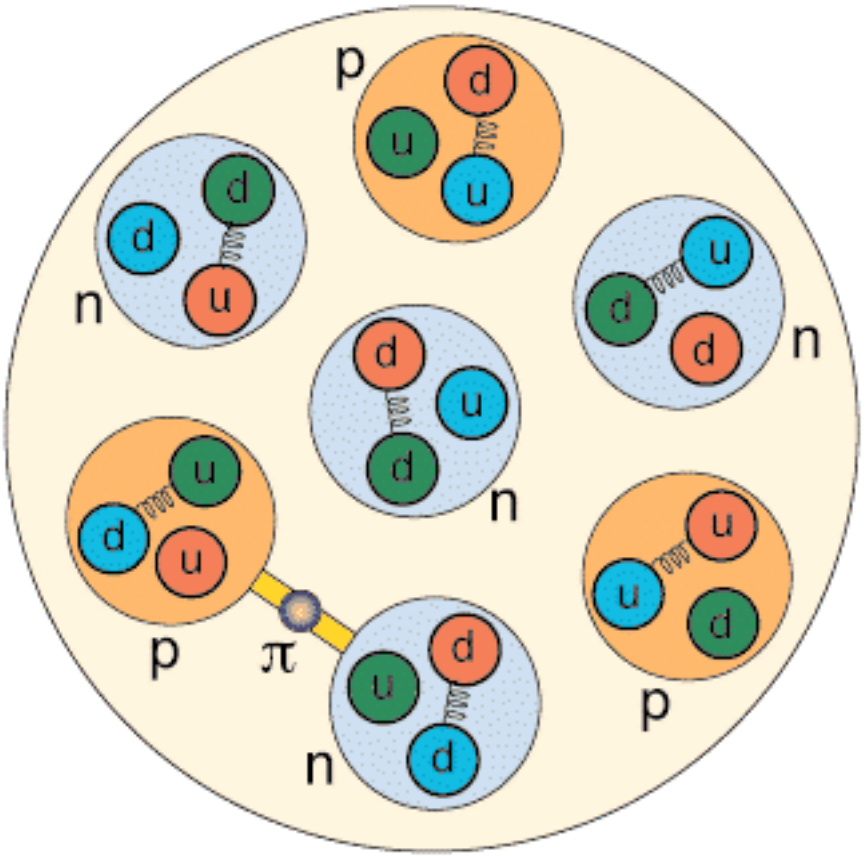
$R = \sigma(e^+e^- \rightarrow q\bar{q})/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$

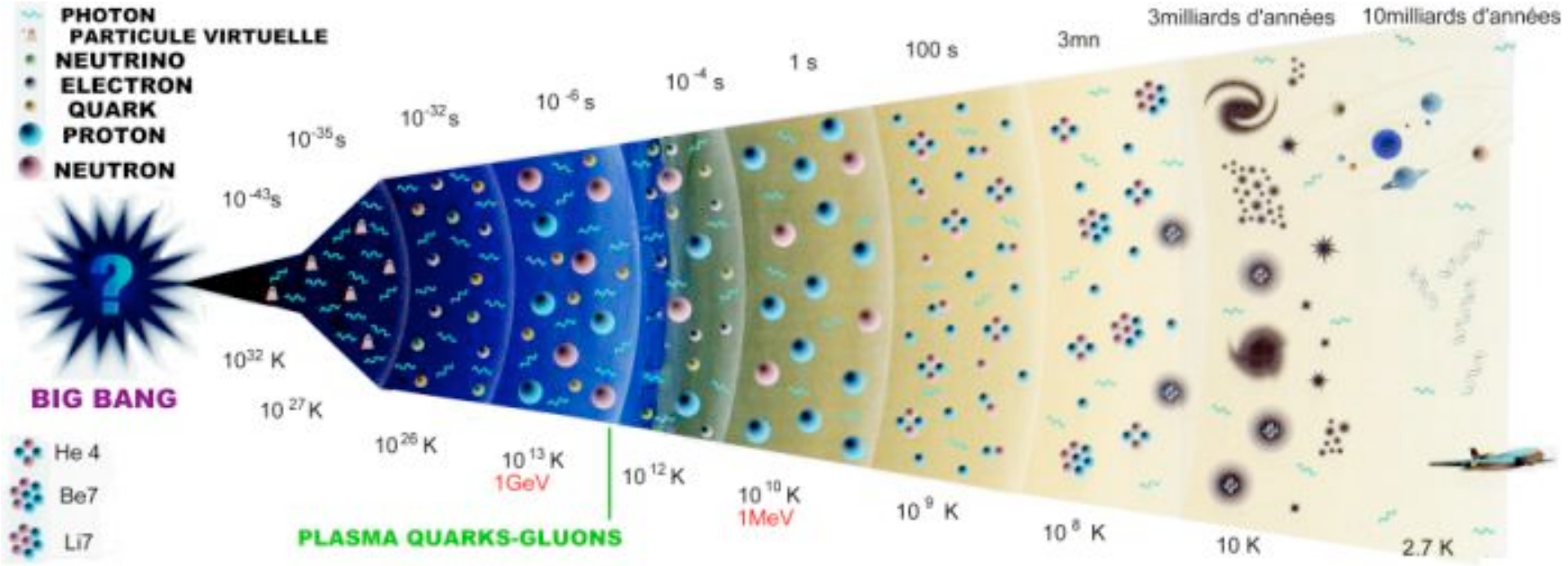


β-decay




proton
neutron
u
d
u
d
d
u
1.6 fm


p
d
u
u
n
d
d
u
d
u
n
d
u
d
n
u
d
u
p
π
d
u
d
n
u
u
d
p


PHOTON
PARTICULE VIRTUELLE
NEUTRINO
ELECTRON
QUARK
PROTON
NEUTRON
?
BIG BANG
He 4
Be7
Li7
10 -43s
10 -35s
10 -32s
10 -6 s
10 -4 s
1 s
100 s
3mn
3milliards d'années
10milliards d'années
10 32 K
10 27 K
10 26 K
10 13 K
1GeV
10 12 K
10 10 K
1MeV
10 9 K
10 8 K
10 K
2.7 K
PLASMA QUARKS-GLUONS

Petaquark State